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Long-awaited study shows chlorine can give the pit production mission a boost

Lab employees gather data that will streamline key processes for pit production

The Chlorine Worth Study team on-site at the National Criticality Experiments Research Center. Left to right: Gabrielle Ambrosio (AMPP-4); Leah Berman (AMPP-4), Theresa Cutler (NEN-2), Jesson Hutchinson (NEN-2), Christopher Lopez (AMPP-4), David Kimball (AMPP-4). The team is standing in front of the critical assembly control center, which collects data for the study such as neutron release and temperature changes.

As much of America ramped down for winter break in 2021, a small team composed of members of both the Actinide Materials Processing & Power (AMPP) and the Nuclear Engineering & Nonproliferation (NEN) divisions found themselves in the middle of Nevada performing experiments with chlorine and plutonium, watching the very results they'd long hoped for roll in — just in time for the holidays.

The Chlorine Worth Study Experiment was performed at the Laboratory's National Criticality Experiments Research Center (NCERC) at the Nevada National Security Site (NNSS) and completed in December 2021. The experiment operated with funding support from Los Alamos Plutonium Operations Material Recycle and Recovery (NA-191) and provided game-changing results that will support pit production and plutonium missions in TA-55's Plutonium Facility (PF-4).

Absorbing reactivity

The experiment, known as the Chlorine Worth Study, consisted of layering sheets of clad plutonium plates, a sheet of chlorinated polymer and a sheet of polyethylene — essentially physically simulating plutonium in chlorinated aqueous solution. As the layers come together, neutrons coming off the plutonium are slowed by the polymer, which makes them more likely to be taken up by the plutonium nuclei and release more neutrons,

yielding an increase in reactivity and an approach to criticality. But with chlorine also present to consume neutrons, the question is — how much plutonium is necessary to go critical?

The results were exactly what the group hoped for: The presence of chlorine simply made the plutonium safer.

“Chlorine acts as an absorber to neutrons, which are your reactive element,” said **David Kimball**, the first line manager for the aqueous chloride processing group. “If the materials that would fuel a reaction that could go critical are being eaten by the chlorine, that means you need more material [as in plutonium] for these systems to go critical. This means adding chlorine while working with plutonium makes it a lot safer and less reactive.”

The data, though, wasn’t surprising to this team of researchers, many of whom have been working with chlorine and plutonium for years in the aqueous chloride processing line in PF-4. Aqueous chloride processing is the means by which plutonium (and sometimes americium) is separated from the salt feeds it resides in. These salt feeds are the byproducts of pit production — essentially, the leftover metals after a pit is made. The team knew chlorine made plutonium safer, and it was simply time to prove it.

Chlorine > Water

Their results will impact criticality safety programs across the country, where most safety limits are based on how plutonium reacts in water. In places like TA-55 where aqueous chloride processing takes place, workers could potentially be getting work done more quickly and more streamlined if the criticality safety limits reflected this new research — which it soon will (the team hopes to have new limits implemented by Spring 2023).

Future new limits based on this experiment will also lend itself to more recycling of metal materials in PF-4 and fewer waste shipments as the increased throughput can be immediately reused in pit production processes.

Critical research in criticality

Theresa Cutler (left) assists as Leah Berman (right, AMPP-4) loads plutonium plates for the experiment. The plutonium is sealed in a stainless steel jacket, or cladding. The outer surface is contamination free and is checked by the radiological control technicians prior to handling. This provides a unique experience for employees like Berman to work with metal outside of a glovebox.

NCERC is a Lab-operated facility that resides at NNSS. Lab employees like **Theresa Cutler** (NEN-2) spend a lot of time working there due to the facility's unique criticality experiment capabilities. Cutler's group performs experiments that support nuclear criticality safety programs, just like the one at TA-55 that ensures worker safety across the complex.

Cutler, an R&D engineer who's worked at the Lab for eight years, was involved in designing the chlorine experiment since June 2020 — it took 18 months to get to the point of implementing the study. While that seems like a long stretch, Cutler said that's actually a really fast schedule for most of their work.

"This was the first experiment our group has done directly in support of PF-4 operations that has such a timely impact," Cutler said. "But it's not over — now that the experiment is complete, we're on the hook for a 500-page document and an extensive review process to actually implement changes based on what we learned."

Building a house for the future

Kimball knows that all of these terms — chloride, aqueous, criticality — aren't exactly self-explanatory to the general public. A master of metaphors, he explained that the purpose of this experiment is like building a house close to a large body of water.

"Our criticality safety limits are like a house — depending on how close to the ocean you are, you design and build a house with certain precautions. In the case of our chlorine use, we didn't know how close to the ocean we were. This experiment helps us know exactly how close we are so we can be accurate in our planning."

Conops, communication, collaboration

PF-4 and NCERC are similar in their capabilities to manage and process hazardous and radioactive materials, but as different facilities with different processes, they also can provide a lot of lessons and ideas for the employees who work there.

Kimball said that his team in AMPP getting to travel to Nevada and work with the experiments firsthand was an eye-opening, perspective-shifting experience for them.

"To see how we operate at TA-55 and how they operate at NNSS in terms of conduct of operations and safety, communications and how their teams are organized — it all gave us a sense of perspective and provided a lot of new ideas," Kimball explained. "The experience will help us build future collaborations and exchange what we have to offer, while giving our existing staff a deeper understanding of the work."

Cutler agreed, noting that the collaboration was across a lot of divisions and ALDs within the Laboratory. For her, seeing the excitement of new staff coming to Nevada to perform a hands-on experiment was a highlight.

"It was really exciting to have the AMPP employees come out and be a part of the experiment," Cutler said. "That was a huge deal because I could see how much they cared; it went beyond just doing something we were assigned. That and all of the collaborations really revealed how big this mission is."

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